January 2, 2008

Re: Current Claims
U.S. Patent Application No. 10/525,372
Our Ref.: 122800

1. - 43. (Canceled)

44. (Currently Amended) A projection optical system that projects an image of a first plane onto a second plane, the projection optical system comprising:

a lens having a liquid immersed surface;

said lens having a first plane side optical surface shaped such that for light projected onto the second plane through the lens, the marginal ray convergence angle prior to incidence is larger than the marginal ray convergence angle within said lens.

45. (Currently Amended) The projection optical system of Claim 44, further comprising:

at least one positive powered lens element proximal to said lens, and having an aspheric optical surface.

46. (Currently Amended) The projection optical system of Claim 44, further comprising:

a first positive powered lens element proximal to said lens, and having at least one aspheric optical surface; and

a second positive powered lens element between the first positive powered lens element and said lens, and having at least one aspheric optical surface.

47. (Currently Amended) The projection optical system of Claim 44, further comprising a double-Gauss anastigmat arranged to reduce spherical aberration including a third positive powered lens element, a first negative powered lens element, a second negative powered lens element, and a fourth positive powered lens element.

48. (Currently Amended) The projection optical system of Claim 47, further comprising a catadioptric anastigmat comprising a concave mirror and at least one negative powered Schupmann lens.

49. (Currently Amended) The projection optical system of Claim 48, wherein the catadioptric anastigmat comprises two negative powered Schupmann lenses.

50. (Currently Amended) The projection optical system of Claim 49 adapted for use with ultraviolet radiation.

51. (Currently Amended) An exposure apparatus comprising:

an illuminating system, and

the projection optical system according to Claim 44 arranged between the first plane and the second plane and which forms an image of a pattern disposed on the first plane onto a photosensitive substrate disposed on the second plane based on a radiation from the illuminating system.

52. (Currently Amended) An exposing method comprising:

illuminating a mask set on the first plane, and

projecting and exposing a pattern image formed on said mask onto a photosensitive substrate set on the second plane via the projection optical system according to Claim 44.

53. (Currently Amended) A projection optical system that projects an image of a first plane onto a second plane, the projection optical system comprising:

an optical system having a predetermined marginal ray convergence angle; and

a boundary lens having a liquid immersed surface;

said boundary lens is positioned to receive light output from the optical system with the predetermined marginal ray convergence angle, and adapted such that for light projected onto the second plane through the boundary lens the marginal ray convergence

angle prior to incidence is larger than the marginal ray convergence angle within said boundary lens.

54. (Currently Amended) The projection optical system according to Claim 53, wherein the optical system comprises:

at least one positive powered lens element proximal to said boundary lens, and having an aspheric optical surface.

55. (Currently Amended) The projection optical system of Claim 53, wherein the optical system comprises:

a first positive powered lens element proximal to said boundary lens, and having at least one aspheric optical surface; and

a second positive powered lens element between the first positive powered lens element and said boundary lens, and having at least one aspheric optical surface.

56. (Currently Amended) The projection optical system of Claim 53, wherein the optical system comprises:

a double-Gauss anastigmat arranged to reduce spherical aberration including a third positive powered lens element, a first negative powered lens element, a second negative powered lens element, and a fourth positive powered lens element.

57. (Currently Amended) The projection optical system of Claim 56, wherein the optical system further comprises a catadioptric anastigmat comprising a concave mirror and at least one negative powered Schupmann lens.

58. (Currently Amended) The projection optical system of Claim 57, wherein the catadioptric anastigmat comprises two negative powered Schupmann lenses.

59. (Currently Amended) The projection optical system of Claim 58, adapted for use with ultraviolet radiation.

60. (Currently Amended) An exposure apparatus comprising:

an illuminating system; and

a projection optical system according to Claim 53 arranged between the first plane and the second plane and which forms an image of a pattern disposed on the first plane onto a photosensitive substrate disposed on the second plane based on a radiation from the illuminating system.

61. (Currently Amended) An exposing method comprising:

illuminating a mask set on the first plane, and

projecting and exposing a pattern image formed on said mask onto a photosensitive substrate set on the second plane via the projection optical system according to Claim 53.

62. (Currently Amended) A method of projecting an image of a first plane onto a second plane, the method comprising:

passing light having a first marginal ray convergence angle to a boundary lens;

passing light having a second marginal ray convergence angle through the boundary lens; and

passing light from said boundary lens through a layer of immersion liquid to the second plane; wherein

the first marginal ray convergence angle is greater than the second marginal ray convergence angle.

63. (Currently Amended) The projection method of Claim 62, further comprising:

passing light through at least one positive powered lens element proximal to said boundary lens, and having an aspheric optical surface.

64. (Currently Amended) The projection method of Claim 62, further comprising:

passing light through a first positive powered lens element proximal to said boundary lens, and having at least one aspheric optical surface; and

passing light through a second positive powered lens element between the first positive powered lens element and said boundary lens, and having at least one aspheric optical surface.

65. (Currently Amended) The projection method of Claim 64, further comprising:

passing light through a double-Gauss anastigmat arranged to reduce spherical abcrration including a third positive powered lens element, a first negative powered lens element, a second negative powered lens element, and a fourth positive powered lens element.

66. (Currently Amended) The projection method of Claim 65, further comprising passing light through a catadioptric anastigmat comprising a concave mirror and at least one negative powered Schupmann lens.

67. (Currently Amended) The projection method of Claim 66, further comprising passing light through two negative powered Schupmann lenses.

68. (Currently Amended) The projection method of Claim 67, wherein said light is a beam of ultraviolet radiation.

69. (Canceled)

70. (Currently Amended) An exposing method comprising:

illuminating a mask set on the first plane, and

projecting and exposing a pattern image formed on said mask onto a photosensitive substrate set on the second plane with use of the projection method according to Claim 62.

71. (Currently Amended) A catadioptric projection optical system that projects an image of a first plane onto a second plane, the catadioptric projection optical system comprising:

a plurality of lenses including a boundary lens which is arranged at a position closest to the second plane,

wherein the first plane side surface of the boundary lens has a positive refractive power, and

a refractive index of a medium to be disposed at the second plane side of the boundary lens is larger than $1.1 \cdot \alpha$,

where a refractive index of a space disposed at the first plane side of the boundary lens is defined as α.

72. (Currently Amended) The catadioptric projection optical system according to Claim 71, which satisfies the condition as expressed by:

$$0.012 < Cb \cdot D/NA < 0.475$$

where, Cb represents the curvature of said boundary lens on the first plane side; D represents the distance between an optical axis and the outermost point of an effective image forming area, and NA represents the numerical aperture on the second plane side of the boundary lens.

73. (Currently Amended) The catadioptric projection optical system according to Claim 72, wherein at least one optical member having substantially no refractive power is arranged in the optical path between said boundary lens and said second plane; and the optical path between said boundary lens and said optical member, and the optical path between said optical member and said second plane are filled with said medium.

74. (Currently Amended) The catadioptric projection optical system according to Claim 71, wherein at least one optical member having substantially no refractive power is

arranged in the optical path between said boundary lens and said second plane; and the optical path between said boundary lens and said optical member, and the optical path between said optical member and said second plane are filled with said medium.

75. (Currently Amended) The catadioptric projection optical system according to Claim 74, wherein said at least one optical member having substantially no refractive power is detachably arranged in the optical path between said boundary lens and said second plane.

76. (Currently Amended) The catadioptric projection optical system according to Claim 75, wherein the optical member having substantially no refractive power has an adjustable orientation.

77. (Currently Amended) The catadioptric projection optical system according to Claim 74, wherein the optical member having substantially no refractive power has an adjustable orientation.

78. (Currently Amended) The catadioptric projection optical system according to Claim 74, wherein said projection optical system satisfies the condition as expressed by:

$$|P \cdot D| < 1.0 \times 10^{-4}$$

where, P represents the refractive power of said optical member having substantially no refractive power, and D represents the distance between the optical axis and the outermost point of the effective image forming area.

79. (Currently Amended) The catadioptric projection optical system according to Claim 71, further comprising at least one concave reflector.

80. (Currently Amended) The catadioptric projection optical system according to Claim 79, having an effective image forming area eccentric relative to the optical axis, wherein at least one intermediate image is formed in said optical path of said projection optical system.

81. (Currently Amended) The catadioptric projection optical system according to Claim 80, further comprising one image forming optical system, having said at least one concave reflector, for forming said intermediate image; and another image forming optical system for forming a final image on said second plane on the basis of the flux from said the intermediate image; and

a deflecting mirror arranged in the optical path between said one image forming optical system and said another image forming optical system.

82. (Currently Amended) The catadioptric projection optical system according to Claim 81, wherein the following conditional expression is satisfied:

$0.75 < MA/MG3 < 1.1$

where, MA denotes a magnification of the whole optical system, and MG3 denotes a magnification of the another imaging optical system.

83. (Currently Amended) The catadioptric projection optical system according to Claim 81, wherein said another image forming optical system includes an aperture stop, and wherein the number of lens elements arranged on the second plane side of the aperture stop is five or less.

84. (Currently Amended) The catadioptric projection optical system according to Claim 83, wherein all lens elements arranged between the second plane and the aperture stop in the third image forming optical system have positive refractive power.

85. (Currently Amended) The catadioptric projection optical system according to Claim 83, wherein no lens element having negative refractive power is included in the lens elements arranged in the second plane side of the aperture stop.

86. (Currently Amended) The catadioptric projection optical system according to Claim 80, further comprising:

a first image forming optical system for forming a first intermediate image of said first plane;

a second image forming optical system, having said at least one concave reflector, for forming a second intermediate image on the basis of said first intermediate image; and

a third image forming optical system for forming a final image on said second plane on the basis of the flux from said second intermediate image; wherein:

a first deflecting mirror is arranged in the optical path between said first image forming optical system and said second image forming optical system; and a second deflecting mirror is arranged in an optical path between said second image forming optical system and said third image forming optical system.

87. (Currently Amended) The catadioptric projection optical system according to Claim 86, wherein the optical axis of said first image forming optical system is aligned with the optical axis of said third image forming optical system.

88. (Currently Amended) The catadioptric projection optical system according to Claim 87, wherein the following conditional expression is satisfied:

$0.75 < MA/MG3 < 1.1$

where, MA denotes a magnification of the whole optical system, and MG3 denotes a magnification of the third imaging forming optical system.

89. (Currently Amended) The catadioptric projection optical system according to Claim 86, wherein the following conditional expression is satisfied:

$0.75 < MA/MG3 < 1.1$

where, MA denotes a magnification of the whole optical system, and MG3 denotes a magnification of the third imaging forming optical system.

90. (Currently Amended) The catadioptric projection optical system according to Claim 71, wherein the numerical aperture on the first plane side is 0.22 or larger.

91. (Currently Amended) The catadioptric projection optical system according to Claim 71, wherein the light quantity loss occurring upon passing through said medium is 50% or lower.

92. (Currently Amended) An exposure apparatus comprising:

an illuminating system; and

a catadioptric projection optical system according to Claim 71 arranged between the first plane and the second plane and which forms an image of a pattern disposed on the first plane onto a photosensitive substrate disposed on the second plane based on a radiation from the illuminating system.

93. (Currently Amended) An exposing method comprising:

illuminating a mask set on a first plane, and

projecting and exposing a pattern image formed on said mask onto a photosensitive substrate set on a second plane via the catadioptric projection optical system according to Claim 71.

94. (Currently Amended) A projection optical system that projects an image of a first plane onto a second plane, the projection optical system comprising:

a plurality of optically transparent members,

an optical path between the second plane and a first optically transparent member of the plural optically transparent members which is arranged in a position nearest to the second plane to be filled with a first medium,

an optical path between the first optically transparent member and a second optically transparent member arranged adjacent to the first plane side of the first optically transparent member to be filled with a second medium,

the first medium and the second medium have a refractive index larger than 1.1, for an atmosphere having a refractive index of 1, and

a refractive index of the first optically transparent member is different from the refractive indices of the first medium and the second medium.

95. (Currently Amended) The projection optical system according to claim 94, wherein the first medium and the second medium are the same in a kind of the medium.

96. (Previously Presented) The projection optical system according to claim 95, wherein the first optically transparent member has substantially no refractive power.

97. (Previously Presented) The projection optical system according to Claim 96, wherein said projection optical system satisfies the condition as expressed by:

$$|P \cdot D| < 1.0 \times 10^{-4}$$

where, P represents the refractive power of said first optically transparent member, and D represents the distance between the optical axis and the outermost point of the effective image forming area.

98. (Previously Presented) The projection optical system according to claim 94, wherein the first optically transparent member has substantially no refractive power.

99. (Previously Presented) The projection optical system according to claim 98, wherein the first optically transparent member is insertable in an optical path between the second optically transparent member and the second plane.

100. (Previously Presented) The projection optical system according to claim 98, wherein the first optically transparent member has an adjustable orientation.

101. (Previously Presented) The projection optical system according to claim 98, wherein a surface of the second optically transparent member which faces to the first plane have positive refractive power.

102. (Currently Amended) The projection optical system according to claim 101, which satisfies the condition as expressed by:

$$0.012 < Cb \cdot D/NA < 0.475$$

where, Cb represents the curvature of the surface of the second optically transparent member which faces to the first plane; D represents the distance between an optical axis and the outermost point of an effective image forming area, and NA represents the numerical aperture on the second plane side of the projection optical system.

103. (Previously Presented) The projection optical system according to claim 94, wherein the first optically transparent member is insertable in an optical path between the second optically transparent member and the second plane.

104. (Previously Presented) The projection optical system according to claim 94, wherein the numerical aperture on the first plane side is 0.22 or larger.

105. (Previously Presented) The projection optical system according to claim 94, wherein the first optically transparent member has an adjustable orientation.

106. (Previously Presented) The projection optical system according to claim 94, wherein the plurality of the optically transparent member are made of fused silica or calcium fluoride.

107. (Previously Presented) The projection optical system according to claim 106, wherein the first optically transparent member is made of fused silica.

108. (Currently Amended) The projection optical system according to claim 107, wherein all of the plurality of the optically transparent members are made of fused silica.

109. (Previously Presented) The projection optical system according to claim 106, wherein the first optically transparent member is made of calcium fluoride.

110. (Previously Presented) The projection optical system according to claim 94, wherein the first optically transparent member is a plane parallel plate, and the second optically transparent member is a plano-convex lens.

111. (Previously Presented) The projection optical system according to claim 94, wherein a space between a partially area on the second plane and the first optically transparent member is filled with the first medium.

112. (Currently Amended) An exposure apparatus that transfers a predetermined pattern on a photosensitive substrate, comprising:

a projection optical system according to claim 94, arranged between the first plane and the second plane, and that projects an image of the pattern arranged in the first plane onto a photosensitive substrate arranged in the second plane.

113. (Previously Presented) The exposure apparatus according to claim 112, wherein a scanning exposure is performed by relative movement of the projection optical system and the photosensitive substrate.

114. (Currently Amended) An exposure method of transferring a predetermined pattern on a photosensitive substrate, the method comprising:

using a projection optical system according to claim 94, projecting an image of the pattern arranged in the first plane onto a photosensitive substrate arranged in the second plane.

115. (Previously Presented) The exposure method according to claim 114, comprising a step of performing a scan exposure with relative movement of the projection optical system and the photosensitive substrate.

116. (New) A device manufacturing method comprising the steps of:

preparing a predetermined pattern;

transferring an image of the pattern onto a photosensitive substrate with a projection optical system according to claim 44; and

developing the photosensitive substrate.

117. (New) A device manufacturing method comprising the steps of:

preparing a predetermined pattern;

transferring an image of the pattern onto a photosensitive substrate with a projection optical system according to claim 53; and

developing the photosensitive substrate.

118. (New) A device manufacturing method comprising the steps of:

preparing a predetermined pattern;

transferring an image of the pattern onto a photosensitive substrate with use of the projection method according to claim 62; and

developing the photosensitive substrate.

119. (New) The catadioptric projection optical system according to claim 71, wherein the medium includes a liquid.

120. (New) A device manufacturing method comprising the steps of:

preparing a predetermined pattern;

transferring an image of the pattern onto a photosensitive substrate with a catadioptric projection optical system according to claim 71; and

developing the photosensitive substrate.

121. (New) A device manufacturing method comprising the steps of:

preparing a predetermined pattern;

transferring an image of the pattern onto a photosensitive substrate with a projection optical system according to claim 94; and

developing the photosensitive substrate.